PATENT APPLICATION

METHOD OF MANUFACTURING A CULTURE MEDIUM

CROSS-REFERENCE TO A RELATED APPLICATION

This application claims priority to, and the benefit of, two patent applications filed in The Netherlands, Patent Application Nos. NL 1022683, filed on February 13, 2003, and NL 1023354, filed on May 7, 2003, and the specifications and claims thereof are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention (Technical Field):

The present invention relates to a method of manufacturing a culture medium for plants comprising mixing organic and/or inorganic particulate base materials with a binding agent, heating the mixture to make it at least semi-fluid, then cooling the mixture to solidify it.

Description of Related Art:

Note that the following discussion refers to a number of publications by author(s) and year of publication, and that due to recent publication dates certain publications are not to be considered as prior art vis-a-vis the present invention. Discussion of such publications herein is given for more complete background and is not to be construed as an admission that such publications are prior art for patentability determination purposes.

The use of culture mediums is generally known and practiced in several fields such as, for example, in market gardening. Particularly in greenhouse cultivation, culture media is generally used for germinating seeds and growing plants. A method of preparing a culture medium is described in the Dutch Patent Application No. NL 1,017,460. That application discloses an organic base material that is

mixed with a polymerizable mixture that is subsequently polymerized. However, the disclosed method requires the addition of a foaming agent if it is desired that the polymer matrix have an open structure. Having an open structure is generally desirable as it improves water absorption. However, the composition of the culture medium obtained by the disclosed method is very hard. The hardness is not desirable and that characteristic cannot be improved by adjusting the amount of polymer.

BRIEF SUMMARY OF THE INVENTION

The present invention is a method of manufacturing a culture medium on which plants can be grown comprising: providing a particulate base material and a thermoplastic, biologically degradable binding agent; mixing the base material with the binding agent; heating at least the binding agent to at least partly fluidize it; and cooling the mixture to substantially solidify the binding agent so that it binds at least a part of the base material. The base material can be organic, inorganic, or both organic and inorganic.

The binding agent in the mixture is preferably no more than 25% by weight, and optionally no more than 15%, 10%, 7%, 5%, or 4% by weight. A shaping treatment is performed on the mixture after making the mixture.

The organic base material preferably comprises peat, compost, coconut fibers, coconut granulate, hemp fibers, straw, grass, sawdust, coffee grounds, organic waste, residue from the animal feed industry, and/or residue from the paper industry. Alternatively, the inorganic base material is preferably clay, soil, perlite, rock wool and/or other inert inorganic materials.

The base material is preferably no more than 10mm in size, and optionally, no more than 5mm, 2mm, or 1mm in size.

Optionally, a biologically degradable elastomer is added to the mixture.

The method may further comprise disposing a layer of base material between two layers of the mixture and joining two opposing ends of one layer of the mixture to the opposite ends of the other layer of the mixture so that the two layers of the mixture surround the layer of base material. These steps are preferably performed just prior to heating the base material and binding agent.

Alternatively, the method may comprise disposing a layer of base material on a layer of the mixture and folding the mixture layer over the base material layer so that the mixture layer completely surrounds the base material layer. These steps are performed just prior to heating the base material and binding agent.

To cool the mixture, a cooling substance is supplied. The cooling substance may be a gas, a liquid or fluid and may be provided by force, passively, or naturally.

To shape the mixture, a shape is selected, e.g. culture mats, culture plugs, culture blocks, and/or combinations thereof. The mixture may be compressed to not more than 99% of the mixture's original volume, and optionally, to not more than 95%, 90%, or 80% of the mixture's original volume. The binding agent preferably has a melting point of between approximately 20°C and 130°C, more preferably of between approximately 40°C and 120°C, and most preferably between approximately 60°C and 100°C. Heating the binding agent or entire mixture may comprise applying steam.

The present invention further comprises a composition comprising a culture medium for growing plants, wherein the culture medium comprises a particulate base material of no more than approximately 10 mm in size and a thermoplastic, biologically degradable binding agent in an amount of no more than 25% by weight. The base material can be organic, inorganic, or both inorganic and organic. The base material can comprise at least one material selected from the group consisting of peat, compost, coconut fibers, coconut granulate, hemp fibers, straw, grass, sawdust, coffee grounds, organic waste, residue from the animal feed industry, and residue from the paper industry. The base

material can material can comprise at least on material selected from the group consisting of clay, soil, perlite, rock wool, and other inert inorganic materials. The composition can at least partially envelope a core of base material.

A primary object of the present invention is to provide a method by which a culture medium can be manufactured that has a bonded but open structure.

A primary advantage of the present invention is that it provides a culture medium having a consistency that is substantially the same as the consistency of the base material.

Another advantage of the present invention is that it provides a method by which an environmentally safe culture medium can be manufactured.

Other objects, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, taken in conjunction with the accompanying drawings, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The accompanying drawings, which are incorporated into, and form a part of, the specification, illustrate one or more embodiments of the present invention and, together with the description, serve to explain the principles of the invention. The drawings are only for the purpose of illustrating one or more preferred embodiments of the invention and are not to be construed as limiting the invention. In the drawings:

Fig. 1a is a perspective view of an embodiment of the present invention showing a base material disposed on a layer of mixture of a base material and a binding agent;

Fig. 1b is a perspective view of an embodiment of the present invention showing a base material enveloped by a mixture of a base material and a binding agent;

Fig. 2a is a perspective view of an embodiment of the present invention showing a base material disposed between two layers of a mixture of a base material and a binding agent;

Fig. 2b is a perspective view of an embodiment of the present invention showing a base material enveloped by two layers of a mixture of a base material and a binding agent;

Fig. 3a is a perspective view of an embodiment of the present invention showing a layer of a mixture of a base material and a binding agent;

Fig. 3b is a perspective view of an embodiment of the present invention showing a layer of a mixture of a base material and a binding agent shaped as a cylinder;

Fig. 4 is a perspective view of an embodiment of the present invention showing a mold for shaping the culture medium;

Fig. 5 is a perspective view of an embodiment of the present invention showing a mold for shaping the culture medium and a tray; and

Fig. 6 is a side view of an embodiment of the present invention showing a means for removing a shaped culture medium from a mold.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a method of manufacturing a culture medium for plants comprising mixing organic and/or inorganic particulate base materials with a binding agent, heating the mixture to make it at least semi-fluid, and then cooling the mixture to solidify it.

In the preferred embodiment, the primary steps can be further described as: (1) mixing a particulate base material (organic and/or inorganic materials) with a thermoplastic biologically degradable binding agent; (2) heating at least the binding agent in order to at least partly fluidize it; and (3) cooling the mixture so as to substantially solidify the binding agent. At least a part of the base material becomes bonded by means of the binding agent.

By such a method, a culture medium is obtained having a consistency that is substantially the same as the consistency of the original base material. Also, the structure of the culture medium is substantially the same as the structure of the original base material. These properties of the culture medium obtained by using the method of the present invention make the culture medium very suitable for plant root growth. The culture medium obtained is also very suitable for use in germinating seeds and cultivating the plants.

The amount of binding agent in the mixture is preferably no more than 25% by weight, more preferably no more than 15% by weight, still more preferably no more than 10% by weight, still more preferably no more than 7% by weight, even more preferably no more than 5% by weight, and most preferably no more than 4% by weight. In this way, good bonding of the base material is obtained, it does not disintegrate, and the resulting structure of the culture medium is open such as not to impede root growth.

The particulate base material preferably has a maximum size of 10 mm, preferably a maximum size of 5 mm, more preferably a maximum size of 2 mm, and most preferably a maximum size of 1 mm. This contributes to the culture medium having a suitable structure for root growth.

In order to allow the culture medium to be used immediately after its manufacture, it is preferable that, after mixing the base material and binding agent, a shaping treatment be carried out. Such a shaping treatment may comprise, for example, forming the material into a cylindrical rod. Dividing the cylindrical rods into suitable lengths, provides a tube-shaped culture medium for convenient use in market gardening. Such cylindrical rods are known as "culture plugs". Other shapes are possible, such as culture mats and culture blocks. Such shapes are generally known in various fields such as, for example, in greenhouse cultivation.

The organic base material preferably comprises peat, compost, coconut fibers, coconut granulate, hemp fibers, straw, grass, sawdust, coffee grounds, organic waste, residue from the animal feed industry, and/or residue from the paper industry. Such organic starting materials are generally available and generally do not undergo further processing. The present invention therefore contributes to the recycling of organic waste.

The inorganic base material preferably comprises clay, soil, perlite, rock wool, and/or other inert inorganic materials. This ensures that inorganic materials are recycled.

In another embodiment of the invention an elastomer, preferably a biologically degradable elastomer, is added when mixing the base material and binding agent. Doing so makes it possible to reduce the amount of binding agent. The proportions of elastomer and binding agent may be varied so as to produce a culture medium with the desired properties. Adding an elastomer provides the practical advantage of endowing the mixture with permanent elastic properties. Depending on the glass temperature of the elastomer, elastic properties are retained even at lower temperatures.

Heating of the binding agent is preferably done by applying steam, more preferably dry steam (i.e., steam containing only water in the gas phase and not in a condensed state). If steam is added to the mixture upon mixing, a rapid heating of the mixture can be achieved. If dry steam is used, an effective heating of the mixture is ensured and an excessive addition of water is avoided. Supplying a low pressure steam (e.g., 0.5 bars overpressure at a temperature of 112°C) is sufficient. Such a supply of steam brings the mixture, within a few seconds, to a temperature of approximately 100°C. The heating time required is dependent on the amount of steam and the amount of mixture.

As heating can occur quickly, only a limited amount of water is added to the mixture. Steam is simply introduced into the mixture by means of injection lances, thereby easily ensuring an even distribution of the steam supply and thus an even heating of the entire mixture. A person skilled in the art is quite capable of optimizing the number of injection points and the amount of steam.

In another embodiment, magnetron radiation is used to heat the mixture. Magnetron radiation has the advantage of heating the mixture without any physical contact being made on the mixture. However, satisfactory measures have to be taken in order to avoid the leakage of magnetron radiation from the heating installation to the environment.

In another embodiment, infrared radiation is used to heat the mixture. However, infrared radiation quickly heats the outer layer of the mixture, but the bulk of the mixture is heated less quickly. The heat conduction to the bulk is slow. As a result, the outer layer of the mixture can dry out. Heating by means of magnetron radiation causes only a slight degree of drying out. Heating by means of steam causes no drying out of the mixture at all.

The culture medium manufactured in accordance with the present invention is preferably cooled by means of a forced supply of, for example, a gas, liquid, or fluid. However, it is also possible to produce the transition of the mixture to the solid form by means of unforced, natural cooling. Depending on the ambient temperature, cooling in this manner occurs within several minutes to several hours.

If forced cooling is not desirable, the culture medium can be provided with a covering. Such a covering may comprise, for example, thin paper or another similar, biologically degradable material. This covering must be strong enough to last during the period of cooling, until the thermoplastic, biologically degradable polymer has solidified sufficiently. Such a covering may, for example, degrade biologically or otherwise. The material needs only to have a consistency that is durable such that it maintains integrity and does not simply fail during the period in which the culture medium has not yet developed its own firmness.

Preferably, the binding agent is substantially solid when the culture medium has an ambient temperature or work temperature.

The melting point range of the thermoplastic, biologically degradable polymer is preferably at temperatures ranging from approximately 20 to 130°C, more preferably from approximately 40 to 120°C, and most preferably from approximately 60 to 100°C. The manufactured culture medium obtained by the method of the present invention then has a good form retention at room temperature (approximately 18°C). At work temperatures above 20°C, the polymer's melting point range preferably begins at a higher temperature than the work temperature so as to provide the culture medium with a desirable form stability during use.

The biologically degradable polymer may be any polymer that does not form any harmful substances during its degradation. A choice may be made from, for example, the following groups:

1) biologically degradable polyesters such as statistic, aliphatic aromatic copolyesters based on the various monomers of butene diol, adipic acid, and terephthalic acid;

2) polylactic compounds, including the A and the D variants;

3) polyhydroxybutyrate (PHB) compounds and polyhydroxyalkanoate (PHA) compounds; and

4) starchy compounds.

Examples of suitable representatives from the groups mentioned above are the following: polylactic acid, starch, polyesteramide (BAC), poly-ε-caprolactone, (e.g., the product Mater BI from Novamont SpA in Italy).

Finally, reference is made to a preferred embodiment of the shaping step, wherein during shaping, a partial compression of the mixture is accomplished. This compression occurs preferably up to approximately 99%, more preferably up to approximately 95%, still more preferably up to approximately 90%, and most preferably up to approximately 80% of the original volume of the mixture. In this way, the binding agent and base material are slightly better mixed, allowing the binding agent to flow more effectively around the base material than would be the case without such compression. This improves the bonding of the particles of the base material. The same amounts of binding agent produce a better bonding between the particles of the base material or, in order to obtain a similar bonding, the amount of binding agent is reduced with such compression.

Turning now to the figures, Fig. 1a shows how bottom layer **1** has second layer **2** placed thereon. First layer **1** comprises a mixture of base material and binding agent. The base material comprises an organic and/or inorganic material. Examples of organic materials are peat, compost, coconut fibers, coconut granulate, hemp fibers, straw, grass, sawdust, coffee grounds, organic waste, residue from the animal feed industry, and residue from the paper industry. Examples of inorganic base materials are clay, soil, perlite, rock wool and other inert inorganic materials. The term "inert inorganic materials" refers to the respective material exhibiting no reactivity in the intended application and having no harmful effect on the germination of seeds or on plants growing therein. Other organic and/or inorganic materials may also be used preferably in accordance with the present invention.

The binding agent preferably is a thermoplastic, biologically degradable, binding agent. A very suitable example of a binding agent is an ε-polycaprolactone. Such a material can be obtained from Dow Chemical, under the trademark Tone® Polymers. Such an ε-caprolactone is biologically degradable and melts slightly at temperatures above approximately 60°C.

Layer **2** comprises base material. To layer **2**, no binding agent has been added in the embodiment shown.

Fig. 1b shows that bottom layer **1** has two sides **3**, **4**. In a shaping operation, bottom layer **1** is folded such that sides **3**, **4** come together so that second layer **2** is surrounded by first layer **1**.

Although in Fig. 1a, bottom layer **1** is shown as a coherent layer, it is clear that bottom layer **1** in large part also comprises of base material. Therefore, in practice, the difference between bottom layer **1** and top layer **2** is a less obvious, or not visible or not obvious at all.

Although the thickness in bottom layer **1** shown in Fig. 1a is relatively insignificant, in practice, layer **1** may be considerably thicker. The properties of the shaped product depend on the thickness of layer **1**. The properties of the shaped product of course also depend on the amount of binding agent used.

Fig. 2a shows a variation of the embodiment illustrated in Fig. 1a. In the Fig. 2a embodiment, bottom layer **1** comprises base material and binding agent and is partially covered by second layer **2**. On second layer **2,** third layer **5** is provided, comprising base material and binding agent. Second layer **2** is identical to layer **2** as shown in Fig. 1a.

Top layer **5** depicted in Fig. 2a has two sides **6**, **7**. A shaping treatment of the construction as shown in Fig. 2b results in the shape depicted in Fig. 2b. In Fig. 2b, sides **3**, **4** of bottom layer **1** are abutted against the sides **6**, **7** of top layer **5**. When subjecting this shaped product to a treatment in which the binding agent is made fluid, adhering to and surrounding the particles of the base material, respective sides **3**, **6** or **4**, **7**, respectively, also adhere to each other. Therefore, according to the method of the present invention, a culture medium is obtained having a coherent outer layer which comprises a base material and a binding agent and a coherent inner layer comprising a base material only.

Figs. 3a and 3b depict another embodiment in which layer **1** is shown comprising a base material and a binding agent. Layer **1** is subjected to a shaping treatment, after which a culture medium is obtained comprising entirely the base material and binding agent. The amount of binding agent is preferably, for example, no more than approximately 25% by weight, more preferably no more than approximately 15% by weight, and most preferably no more than approximately 10% by weight, related to the amount of base material, such that a culture medium is obtained whose consistency is substantially the same as the consistency of only the base material. The binding agent is preferably no more than 7% by weight, more preferably no more than 5% by weight, and most preferably no more than 4% by weight, in relation to the amount of base material.

It is obvious that the invention is not limited to the embodiments of the invention as shown in the figures and described heretofore. Although the figures show only a shaping into a strand, it is also possible to manufacture the material according to the invention in a mold of, for example, the form of a cube measuring, for example, 10 x 10 x 10 cm, or in bar-shaped molds measuring, for example, 100 x 20 x 10 cm, etc. The culture media can be manufactured in larger shapes. The culture media shapes may conveniently be used as culture mats of culture blocks, etc., in so-called "substrate cultivation". Substrate cultivation is generally employed in market gardening such as, for example, in the cultivation of greenhouse vegetables such as tomatoes, peppers, and the like.

In another embodiment, the manufacture of, for example, culture plugs or other formed objects may be accomplished using means as shown in Figs. 4 to 6. Fig. 4 shows mold **8** comprising top side **9** and bottom side **10**. In mold **8,** holes are made all the way through mold **8** so as to form opening **11** at top side **9** and opening **12** at bottom side **10**. Opening **11** at top side **9** is slightly larger than opening **12** at bottom side **10**. The holes are filled from top side **9** with the mixture of particulate base material and thermoplastic, biologically degradable, binding agent. This may be done by applying the mixture using, for example, a scraping knife at top side **9** of mold **8**, thus filling the holes. Mold **8** may optionally be maintained at a constant elevated temperature, being such that the thermoplastic polymer will at least partly fluidize. This causes the polymer and base material to bond in mold **8**. In order to be able to

properly fill the holes in mold **8**, mold **8** is preferably placed upon a base, so that openings **12** at bottom side **10** are closed off.

In a subsequent step, mold **8** is inverted, whereby top side **9** is oriented at the bottom and bottom side **10** is oriented at the top. This inversion is illustrated in Fig. 5. There are only two holes shown in the mold **8**; it is, however, obvious that in practice a plurality of holes may be provided in mold **8**. Beneath mold **8** there is tray **13**, such that the holes in mold **8** are aligned with recesses in tray **13**. Culture media in the holes in mold **8** may subsequently be pushed downward from side **10** of mold **8**, thereby placing the culture media in the recesses in tray **13**.

Pressing out the shaped culture media from mold **8** may be facilitated if the holes have a slightly conical shape. The opening in bottom side **10** is preferably slightly smaller than the opening in top side **9**. In this way, the hole passing through mold **8** receives a conical shape. When mold **8** is inverted (as shown in Fig. 5), the shaped culture medium can easily be pressed out of mold **8**.

Fig. 6 shows a further embodiment of pushing the shaped culture medium out of the hole in mold **8**. For this step, push-out member **14** is placed above hole **12**. This push-out member **14** is pushed downward in the direction of opening **11** – that is to say through the hole in mold **8**, thereby pushing the shaped culture medium out of the hole in mold **8**. When mold **8** is placed upon tray **13** so as to be in contact therewith, it suffices that push-out member **14** is moved to opening **11**. When the culture medium is introduced into the recesses in tray **13**, the end of push-out member **14** is still in contact with the top side of the shaped culture medium. Also as shown in Fig. 6, push-out member **14** is provided with spindle **15** which is moved downward from the end of push-out member **14**. In an execution situation, spindle **15** is positioned as shown by the dotted lines with reference number **16**. When the end of the push-out member is situated just above the surface of the culture medium and spindle **15** is employed, an opening is formed in the culture medium (not shown). This greatly facilitates the placing of, for example, young plants, cuttings or seeds and the like in the culture medium. The

formation of an opening in the culture medium is carried out while the temperature is still within the melting range of the polymer or above, the opening will, on cooling, remain intact.

In the figures, the conical form of the holes in mold **8** is exaggerated. In practice, the difference between the sizes of openings **11** and **12** may be much smaller, so that the ease of pushing out the culture medium from mold **8** is maintained.

Heating the binding agent in order to fluidize it may be accomplished in various ways. As already mentioned herein, steam heating is preferred. For this purpose steam may be injected into the mixture by means of injection lances so that, depending on the number of injection points, an even heating of the mixture is accomplished. A person skilled in the art is capable of determining the number of injection points as well as the amount of steam to be injected so as to ensure a suitable heating of the mixture. Preferably, dry steam is used, that is to say steam from which condensed water has been removed. In one embodiment, it is possible to, within a few seconds, raise the mixture's temperature to approximately 100°C. This is possible even if the mixture has a layer thicknesses of up to 10 cm or more. To this end, for example, steam at a pressure of 0.5 bars overpressure and a temperature of 112°C may be used. Due to the great heat capacity of the steam, only a very small amount is necessary for heating the mixture.

Infrared radiation and/or magnetron radiation may also be used to provide heat. To use magnetron radiation, the consistency of the binding agent needs to be such as to enable it to be heated by means of magnetron radiation. The binding agent may also be heated indirectly by heat transfer via water contained in the mixture that is heated by magnetron radiation.

If the outer rim of the culture plug, as shown in the Figures 1b and 2b, is provided with a binding agent but the comprises only the base material, it is easy to insert plants into the loose interior of the plug without causing the plug to disintegrate.

Biologically degradable polymers, or polymers that produce no harmful substances during degradation, may be used in the present invention. In other words, the degradation products should not contain any components that are harmful to plants and animals. It is possible to use biologically degradable synthetic polymers or biologically degradable biopolymers. Combinations thereof are also useful. In general, the polymers may be chosen from the following:

1) biologically degradable polyesters such as statistical, aliphatic aromatic copolyesters that are based on the different monomers of butene diol, adipic acid and terephthalic acid;
2) polylactic acid compounds, including the A and D variants;
3) polyhydroxybutyrate (PHB) compounds and polyhydroxyalkanoate (PHA) compounds; and
4) starchy compounds.

Such polymers may be chosen, for example, from polylactic acid, starch, polyester amide or polycaprolactone.

The dimensions of the culture media may vary extensively. For example, the medium may have a shape and size that always fits exactly into a recess in a culture block. Suitable dimensions are plugs having a diameter of approximately 13 mm, 20 mm, and 28 mm. These are generally used in practice.

Some of the polymers have a hydrophobic effect. However, as the culture medium manufactured in accordance with the present invention only comprises the base material and binding agent, such a hydrophobic property of the binding agent is in practice without effect on the water absorbent capacity of the base material. However, the amount of binding agent preferably does not exceed a maximum of approximately 25% by weight.

In order to greatly improve the wettability of the base material, a surface tension reducing agent may be added such as, for example, WMC. This increases the water absorption of the culture medium to be made.

Although the invention has been described in detail with particular reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover in the appended claims all such modifications and equivalents. The entire disclosures of all references, applications, patents, and publications cited above are hereby incorporated by reference.